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Literature review: the cost effectiveness of assistive technology in supporting people with dementia

Report to the Dementia Services Development Trust

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Despite much emphasis on the potential of assistive technologies of many varieties to deliver cost effective ways of supporting people with dementia, and clear indications of this potential, rigorous cost-effectiveness studies of these technologies for this group remain largely absent. The review includes consideration of the indicative evidence. This report describes the process and results of the literature review. Extensive searches identified a large literature, of which 59 items were systematically reviewed and quality assessed.

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Background and purpose

The literature review aimed to identify and assess evidence regarding the costs and benefits of assistive technology in supporting people with dementia. 'Assistive technology' was defined broadly for the purposes of the review, using definitions given in the DSDC/JIT publication 'Telecare and dementia' (Kerr et al 2010). The term includes:

- 'remote or enhanced delivery of health and social services to people in their own home[1] by means of telecommunications and computerised systems' (Scottish Government 2010)
- '[technological] devices for personal use designed to enhance the physical, sensory and cognitive abilities of people with disabilities to help them function more effectively' (Kerr et al 2010).

The review included both technology offered through formal services and technology for private or personal use. In the context of a policy climate moving increasingly towards personalised services, care at home and support for informal care, both aspects are important.

It was clear from the outset that the evidence base is scattered, that methodologies for assessing cost effectiveness of assistive technology are varied and that outcome measures used are diverse (Deshpande et al 2008, Farmer et al 2005, Rojas and Gagnon 2008). The review process allowed for this wide range of evidence and approaches to be identified and reviewed for inclusion.

The literature on assistive technology in general, including telehealthcare, telemedicine and telecare is very extensive. Assistive technology is often portrayed as offering huge potential for the future, especially in meeting the challenges of an ageing population in a more cost effective way than current modes of service delivery. For example, Scotland's National Telehealth and Telecare Delivery Plan (Scottish Government 2012:6) states 'we simply cannot continue to deliver our services in the current way' and argues strongly for technological solutions as the way forward. However, Audit Scotland's (2011) review found that evaluations had been limited in scope and quality and, in particular, that robust evidence on costs and cost effectiveness was sparse and inconsistent. People with dementia are rarely considered in this wider literature or in the policy documents, and in Scotland at least have been a minority of those receiving technology-based services (4,000 out of 44,000 recipients – Scottish Government 2012). Our review focused specifically on technologies for people with dementia, and did not draw on the wider literature.

Review process

A full account of the review process is in Appendix One. The search terms finally used were refined following initial searches to achieve a balance between sensitivity (finding every relevant study, but with large volumes of irrelevant material) and specificity (more relevant studies but a potential to miss some). The terms were designed to identify a wide range of assistive technology, and to identify any discussion of costs and particularly any systematic costs analysis. Following initial searches, in the light of the volume of material and the time available, the review focused on material published in the last five years: as this is a rapidly evolving field, and given the need to focus on evidence of implementation of technologies rather than pilot studies, more recent material was considered more relevant. Furthermore, as detailed in Appendix One, more than half the items identified were

[1] Including communal living establishments such as care homes and sheltered housing.

published during the last five years. In addition to the searches of databases, specific Northern Ireland related work was sought via the University of Ulster and CARDI (Centre for Ageing Research and Development in Ireland).

Following review of abstracts for relevance 82 full texts were examined. Fifty-nine were included for full evaluation, with 23 being rejected after full text examination.

Each of the items examined in full was read in detail by a researcher. They were assessed for relevance for the review, and if deemed relevant to the study were then assessed using our proforma review tool. This tool collects data regarding the content and conclusions of each item, and also includes a quality review. The Review templates are based on CRD[2] Report no 4, EPOC[3] checklists and CASP[4] assessment criteria. The review process thus provided rigorous quality assessment of different types of research.

Results

Characteristics of studies included

Table 1 lists the types of studies that were included. The majority of studies included were research based.

Table 1: Types of studies

Type	Number	Percent
Describes a single research study	27	46
Reviews two or more research studies (i.e. a literature review)	10	17
Presents the Author's own views, experiences or opinions	2	3
Describes a product or services without reporting research	3	5
Reports on evaluation of a pilot project or technology based intervention	6	10
Describes a project related to the design, development or use of technology for people with dementia or to support services for people with dementia	11	19
Total	59	100

The large majority of texts (73%) concerned 'high' technology, referring to ICT and/or electronic components. One third of the applications were portable (such as tracking devices or items which could be moved from place to place) and a further third were static, such as fixed monitors or assistive devices in the home. The remainder have both portable and fixed elements, do not have a tangible form (e.g. a support intervention delivered using ICT) or are otherwise difficult to categorise. The technologies were variously controlled by the user, operated remotely or pre-programmed. The 'users' of the devices are listed in Table 2, which shows how widely targeted the devices were: many were intended for use by several of the categories identified.

[2] Centre for Reviews and Dissemination, part of the National Institute for Health Research (NIHR)
[3] Effective Practice and Organisation of Care Group, a Review Group of The Cochrane Collaboration
[4] Critical Appraisal Skills Programme, (http://www.sph.nhs.uk/what-we-do/public-health-workforce/resources/critical-appraisals-skills-programme)

Table 2: Users of assistive technologies for people with dementia

Users of technologies	Number	Per cent
People with dementia	44	75
Family and caregivers living with a person with dementia	27	46
Non-resident family and caregivers	11	19
Professional caregivers (e.g. home care workers)	11	19
Health care professionals	13	22
Social care professionals	6	10
Municipal/local health authorities	1	2
Municipal/local authorities with duties to provide social care	2	3
Other health care providers	1	2
Other social care providers	1	2
Other	3	5

Table 3 lists the purposes of the assistive technologies covered in the included studies. Again some devices were multi-functional and therefore appear in more than one category. The range of functions is significant, as it presents challenges in terms of assessing cost effectiveness, as we will demonstrate further.

Table 3: Functions of assistive technologies in the studies included.

Function	Number	Percent
Memory-related (e.g. appointment reminder systems)	15	25
Mental stimulation for people with dementia (e.g. 'brain training' software or devices)	15	25
Entertainment and / or leisure-related	7	12
Walking-related (e.g. walking sticks, navigational aids for people with dementia, GPS systems)	16	27
Medications management (e.g. automated pill dispensers)	7	12
Monitoring of physiological parameters (e.g. heart rate, blood pressure, blood sugar, etc.)	3	5
Personal emergency alarm systems (e.g. emergency pendant)	8	14
Home-based monitoring and surveillance (i.e. movement sensors, cameras, pressure pads, door sensors, etc.)	22	37
'Smart' home installations other than monitoring and surveillance technologies (e.g. environmental controls, video entry systems, etc)	10	17
Domestic use Assistive Technology (e.g. easy grip kitchen utensils, stair lifts)	4	7
Education (e.g. web-based training programmes and online information resources)	7	12
Improved communication (e.g. 'Talking Mats' for people with dementia, shared electronic records for health and social care professionals)	7	12
Remote consultation with people with dementia and co-resident	8	14

Function	Number	Percent
carers		
Remote peer support (e.g. online communities and forums for people with dementia or carers)	5	8
Remote professional support (e.g. videoconference facilities between local health and social care organisations and remote specialist treatment centres)	6	10
Remote informal caregiving (e.g. internet-accessible home monitoring systems for working carers)	5	8
Information exchange (e.g. of data between support organisations)	6	10
Scheduling (e.g. carer visiting times, hours, allocation of carers, etc.)	3	5
Other	20	34

Table 4 lists the locations in which the technologies included were designed to be used. Again, several could be used in more than one possible location. The table indicates that the aim to focus on technologies for use in the home was achieved, whilst some of the technologies included could also be used in public facilities.

Table 4: Locations for technologies

Locations	Number	Per cent
Private dwellings (i.e. the homes of informal carers or of people with dementia living in the community)	42	71
Care homes	16	27
Hospitals or other secondary health care facilities	5	8
Primary care medical facilities (e.g. GP surgeries, dental surgeries)	0	0
Day centres or other non-residential care facilities	4	7
Municipal / local authority social work departments	1	2
Other service providers' premises (e.g. care scheduling technologies for use in private or third sector home care providers' premises)	1	2
No specific location (e.g. navigation aids and GPS tracking devices)	3	5
Other	7	12

Table 5 highlights the wide range of potential providers of technologies. In this literature, only ten studies (17%) refer to technologies which people with dementia and/or their informal carers have obtained for themselves[5]. As we noted above, this type of use of technologies is likely to become more significant given current policy directions.

[5] It should be noted that the literature did not always provide this information, especially where the study was of a pilot or newly developing device.

Table 5: Providers of technology

Provider	Number	Per cent
Primary health care provider (i.e. GP practices, dentists, opticians, pharmacists, etc.)	3	5
Secondary health care provider (i.e. technology provided by hospitals or specialist services requiring referral from a primary care provider)	8	14
Third sector health care provider (including voluntary and not-for-profit organisations)	3	5
Private sector (for profit) health care provider	6	10
Municipal / local authority social work department	5	8
Third sector social care provider (including voluntary and not-for-profit organisations)	3	5
Private sector (for profit) social care provider	3	5
The person with dementia and/or their informal carers	10	17
Other	29	49

The studies focus on a wide range of outcomes: these can relate to system level outcomes, personal level clinical, psychosocial or functional outcomes, and/or outcomes relating to people's interaction with services. In some cases, these are outcomes sought by those who deliver the technologies. In others, they are outcomes determined by the researchers involved. In many cases, studies consider a range of possible outcomes. Depending on the outcomes measured, the assessment of cost-effectiveness is likely to produce different results: we will discuss this point further below. The following tables (6-10) indicate the range of outcomes considered and the frequencies of consideration of each of these. In each case, more than one outcome could be included, so the percentages do not add up to 100.

Table 6: System level outcomes

Outcome	Number	Per cent
Hospital admissions	5	8
Re-hospitalisations	4	7
Length of hospital stay	1	2
Quality of care	22	37
Cost of care	17	29
Cost savings	23	39
Frequency and/or length of home visits by formal caregivers	11	19
Number of informal caregiver visits	12	20
Number of urgent medical visits	8	14
Number of urgent medical visits to GPs	2	3
Number of visits to hospital Accident and Emergency departments	8	12
Technology usage rate	17	29
Access to interventions	8	14
Use of long-stay hospital / care home services	5	8
Need for transportation	2	3
Avoidance of travel	8	14

Outcome	Number	Per cent
Provision of information within a given time interval	6	10
Incorrect use of technology	3	5
Other system level outcome not listed	12	20
No system level outcomes were considered in this publication	12	20
Other	21	36

Table 7: Person level clinical outcomes

Outcome	Number	Per cent
Self management / self care / self monitoring	32	56
Health-related quality of life	17	30
Depression	7	12
Health status	15	26
Mental health status	15	26
Other person level clinical outcome not listed	12	21
No person level clinical outcomes were considered in this publication	8	14
Other	16	28

Table 8: Person level psycho social outcomes

Outcome	Number	Per cent
Self-efficacy	20	34
Confidence	14	24
Self-esteem	11	19
Adherence / Compliance with intervention	14	24
Quality of Life	32	54
Patient knowledge	16	27
Technology use / non-use	31	53
Ability to live independently	32	54
Sense of security	18	31
Social participation	11	19
Subjective well-being	16	27
Lifestyle changes	12	20
Other person level psychosocial outcomes not listed	15	25
No person level psychosocial outcomes were considered in this publication	7	12
Other	14	24

Table 9: Person level functional outcomes

Outcome	Number	Per cent
Improvements in the performance of ADLs	21	36
Ability to recall and carry out tasks accurately	19	32
Improvements in physical attributes (strength, balance, etc.)	5	8
Other person level functional outcomes not listed	19	32
No person level functional outcomes were considered in this	17	29

publication		
Other	18	31

Table 10: Service interaction outcomes

Outcome	Number	Per cent
Person with dementia-provider satisfaction	23	39
Service acceptability	17	29
Service use	23	39
Other service interaction outcomes not listed	12	20
No service level interaction outcomes were considered in this publication	22	37
Other	12	20

Discussing costs and benefits

The publications considered costs and benefits in a variety of ways. In terms of identifying costs and benefits, these were identified to occur for a range of stakeholders, as Table 11 illustrates.

Table 11: Costs and benefits for whom

Stakeholders	Costs		Benefits	
	Number	Per cent	Number	Per cent
People with dementia	28	48	52	88
Family and informal caregivers	18	31	37	63
Health and/or care workers	13	22	23	39
Health and/or social care provider organisations	11	19	20	34
Local communities	0	0	1	2
The publication does not refer to costs or benefits	19	33	0	0
Other	5	9	3	5

Table 12: Types of costs and benefits

Type	Costs		Benefits	
	Number	Per cent	Number	Per cent
Financial/economic	30	51	36	62
Physical/physiological	15	25	31	53
Psychological	26	44	42	72
Social	16	27	29	50
Organisational	9	15	9	16
Societal	4	7	4	8
The publication does not refer to costs or benefits	14	24	1	2
Other	4	7	9	16

Chandra and Skinner (2011) have produced a classification of technologies in healthcare that divides evidence into three types: first, technologies that are low risk and suitable for everyone in the population (described as 'home run' technologies); second, technologies that are cost effective for some, but are not necessarily universally appropriate or efficacious; thirdly, technologies whose usefulness and cost-effectiveness are uncertain. In our review, readers were asked to classify the

included studies according to Chandra and Skinner's scheme. Table 13 gives the results of these assessments. It should be noted that these general assessments are not based on detailed cost effectiveness analysis, but they represent an overview of the extent to which readers were convinced by the claims made in the reading, much of which referred to intuitive benefits (e.g. preventing a fall manifestly saves healthcare costs) and assessments of potential (e.g. better supported caregivers can keep caring for longer, keeping relatives at home and out of expensive institutional care).

Table 13: Chandra and Skinner classification of included studies

Classification	Number	Per cent
Category I – ''Home run' technologies' - those that are cost-effective and useful for nearly everyone in the relevant population	25	42
Category II – 'Potentially Cost-Effective Technologies with Heterogeneous Benefits' – i.e. those which are cost-effective for some users but have declining marginal benefits in others and so such technologies can still exhibit modest or even poor average cost-effectiveness across all users	25	42
Category III – 'Technologies with Modest or Uncertain Effectiveness' - treatments or technologies where the average value of the procedure leads to poor (or non-existent) cost-effectiveness, or where there is considerable uncertainty about its benefits.	4	7
Other	5	8

The tables give an overview of the emphasis on benefits that exists in the literature. Despite the frequent and wide ranging mentions of costs and benefits however, only ten studies provided any financial data or information. We discuss issues arising from this below.

Quality assessments

The studies were all assessed for quality using criteria appropriate to the methodology used in the study concerned. Table 13 lists the distribution of methodologies. The large number of studies classified as 'other' reflects the quantity of literature describing or presenting reviews of technologies.

Table 14: Studies according to methodologies

Methodology	Number	Per cent
Qualitative Study	11	19
Randomised Controlled Trial (RCT)	2	3
Controlled Clinical Trial (CCT)	1	2
Controlled Before and After Study (CBA)	1	2
Interrupted Time Series (ITS)	0	0
Cohort Study	0	0
Economic Evaluation	2	3

Methodology	Number	Per cent
(Systematic) Literature Review	10	17
Other	32	54
Total	59	100*

*rounding

Table 14 shows the quality assessments for each category of methodology. The quality assessments indicate that whilst strong and rigorous research can be identified, only a minority of studies were assessed as being of high quality, and about 20% were assessed as low quality work. This means that reliable evidence on the costs and benefits of assistive technologies continues to be relatively sparse. In our discussion, we will indicate the strength of evidence referred to and will emphasise the better quality work. We note the importance here of including studies of different types: a Cochrane review (Martin et al 2008) included in our study sought to identify evidence from good quality Randomised Controlled Trials (RCTs) regarding care at home for people with dementia, and found no studies that met the inclusion criteria. Had we set the same criteria, it is likely that our review would have identified only two studies, one (Davis et al 2011) of high quality and one (Wray et al 2010) of medium quality. One high quality Controlled Clinical Trial (CCT) (Rowe et al 2010) was also included. We also note that only two studies (Al Oraibi et al 2012 and Riikonen et al 2010) could be specifically identified as an economic evaluation, despite the more widespread consideration of costs and benefits. Both were assessed as being of low quality: Al-Oraibi et al (2012) largely because of its very small scale and inconclusive results and Riikonen et al (2010) because the study lacked a control group.

Table 15: Quality assessments

Methodology	Number	High	Medium	Low
Qualitative Study	11	5	3	3
Randomised Controlled Trial (RCT)	2	1	1	0
Controlled Clinical Trial (CCT)	1	1	0	0
Controlled Before and After Study (CBA)	1	0	1	0
Interrupted Time Series (ITS)	0	0	0	0
Cohort Study	0	0	0	0
Economic Evaluation	2	0	0	2
(Systematic) Literature Review	10	1	7	2
Other	32	13	12	7
Total	59	21	24	14

Discussion

It is immediately clear from the description of literature above that the assessment of the costs and benefits of assistive technologies for people with dementia is complex. This complexity arises due to a number of issues.

Firstly, 'assistive technology' is a broad term, covering a wide range of possible devices and arrangements. Studies generally have a more limited focus, concentrating on particular subsets of technology. Secondly, the outcomes considered are highly variable. The intended impacts of technology may concern cost reduction, improved services, quality of life for people with dementia,

improvements in caregiver support or any other possible outcomes for different stakeholders. They may involve for example telecare to keep people at home, therefore saving costs of institutional care; activity and reminiscence focused materials which aim to improve quality of life; telemedicine which may seek improved outcomes in terms of QALYs (quality adjusted life years). Thirdly, the population of people with dementia is varied, and people with the condition experience a range of challenges which change over time. Fourthly, there are issues regarding stakeholder interests, and the extent to which assistive technology has costs and benefits for people with dementia and their families, care service providers and/or society as a whole.

We now consider the themes emerging from our qualitative analysis of the literature. The evidence to which we refer comes mainly from materials assessed as of high or medium quality: any references to low quality evidence are specifically highlighted.

Technological issues

Here we consider research on the use of 'off the shelf' technologies, issues of the maturity of technologies, and new developments and implications for people with dementia.

Technology 'off the shelf'

Some of the literature explores the use of existing 'off the shelf' technologies, often with a specific emphasis on their low cost. For example, Armfield et al (2012) review evidence on the use of Skype (free and widely available) by nurses in communicating with people with dementia and their carers at home. They find 'inadequate' evidence of costs/benefits: in particular, they note that though the technology is free, little consideration has been given to potential drawbacks arising from potentially poor connectivity, and the system has not been compared with other low-cost alternatives, such as landline telephones. Armstrong et al (2010) argue that despite indications of potential for 'off the shelf' technologies, there is evidence that they fail because people who buy them are unable to integrate them into their everyday lives: such an approach therefore is not cost-effective from the point of view of individuals. Dutton (2009) considers similar issues in reference to established telecare systems (mature technologies) in extra care housing. She argues that although there is evidence that these can effectively support people with dementia, they are used much less than they could be, and that concerns about installation costs may be a barrier in a situation in which users have to bear the costs.

Maturity of technologies

One reason for the dearth of work which has assessed assistive technology economically is the rapid development of technologies over recent years. Much of the literature focuses on the development of new devices or on pilot projects which implement technology in small numbers of homes. Some exceptions to this are especially significant in terms of understanding the longer term, real system implementation of assistive technology for people with dementia. There are calls in the literature for a focus on more mature technologies and systems. Evans et al (2011) for example note that much of the research has been focused on pilots and new devices. They argue that there is a need for consideration of more mainstream and available products that can be used in real service provision situations.

An important case is that of West Lothian, Scotland, which has been using telecare systems to support older people, including people with dementia, in their own homes since 2001, and has experience of delivering this care to thousands of clients. Kinder (2010) reviews this record and

identifies that over time, West Lothian's telecare system has delivered reduced costs and service users who are more content. Importantly, as Kinder describes, West Lothian did not simply import assistive devices, but integrated telecare into a wholesale reorganisation of local services, which included closing half the care homes in the area and building several new housing with care facilities. The early evaluation of the system (Bowes and McColgan 2006) includes an economic analysis showing that over time, West Lothian reduced health and social care costs and retained quality of care delivered.

It is clear that there are continuing challenges around delivering assistive technology at scale. In addition to the West Lothian example, it is worth noting the Whole System Demonstrator (WSD) projects implemented in England in 2008-2009: the results of the evaluation are currently being published (Steventon et al 2012; Henderson et al 2013[6]). The WSD projects involved people with the long term conditions of diabetes, COPD or heart failure (not dementia). A cluster randomized trial of technologies for data transfer between patients and professionals (telehealth) as part of diagnosis and treatment processes involved 3230 patients in 179 GP practices. Reporting on the trial, Steventon et al (2012) demonstrated that the telehealth did reduce hospital admissions and mortality as compared with usual care over a period of 12 months. The cost effectiveness study (Henderson et al 2013) suggested that the addition of telehealth to the care regime was not cost effective. This was the largest trial of telehealth conducted in the UK. The findings appear contradictory in that reductions in hospital admissions should save costs: however, there is a possibility that telehealth is shifting costs from secondary health services to primary care and to individuals themselves (in terms of informal care provision).

Riikonen et al (2010) conducted a study of twenty nine different technologies covering risk prevention, assistance and emergency issues individually tailored for 25 older people with dementia living at home. This was one of very few studies that attempted any form of economic analysis. Though the quality of the study was assessed as low because there was no control group and the authors' treatment of the costs of living in the community supported by technology is partial, the study suggests living at home could be prolonged by an average of eight months and, making comparison with residential care costs of 3,000 Euros per month over the same period, the authors argue that 'technology taken to homes can be considered to be profitable in the long run' (2010: 42).

New developments and implications for people with dementia

Development costs may be barriers to the adoption of assistive technologies. The literature reviewed identified some of these. Astell et al (2009) suggest that whilst it is highly desirable to include people with dementia in developing assistive devices to support them, this can be costly in terms of the support needed for them to do so: this study raises important questions about the need to ensure that people with dementia can be properly supported, and the associated need to find the additional resources needed to permit this.

Boger et al (2010) however used actors to help assess their COACH system of cognitive support for people with dementia: they obtained useful results, and whilst recognising that there will be a need at a later stage of development of the device to involve people with dementia, demonstrate that this much cheaper approach could have a significant impact on development costs. Another of their

[6] These items were not amongst those reviewed as they do not focus on people with dementia. We note them here because of their significance to the field of assistive technology as a whole.

studies (Mihailidis et al 2008) did involve people with dementia supported by COACH in hand-washing: this study concluded that the technology was promising. However, COACH is an example of a new technology which is far from ready for implementation: this is not uncommon in the literature.

Robinson at el (2009) involved people with dementia in developing new products. They argue that products designed in collaboration may reduce some of the stigma associated with dementia.

Potential savings

Literature frequently refers to potential cost savings, referring to a variable evidence base. Bharucha et al (2009) reviewed technical literature and identified a wide range of commercially available technological devices that they argue have potential to reduce the costs of care: however, they conclude that more research on cost effectiveness is needed, especially in relation to people with dementia. Buettner and Burgener (2010) reviewed ten studies using technologies designed to improve cognitive function, support memory and improve medication adherence. Despite the small scale of the studies reviewed, they conclude that these devices show evidence of potential to save costs by reducing the need for service support. Looking at technologies capable of supporting people with dementia at home during the night, Carswell et al (2009 – a low quality study) refer to potential cost savings in the sense that people may stay in their own homes longer with better night support, reducing calls on formal services. Lancioni et al (2008, 2011, 2013) discuss a system of memory prompts for people with dementia: they claim that this has the potential to reduce costs in that people will need less support from services. Mann et al (2010) review various technological devices and note that the costs of ICT technologies are reducing: this, they suggest, will inevitably make them increasingly cost effective. Mapundu et al (2012) argue for the use of videoconferencing and home monitoring, asserting that these technologies are now reliable, and that they can be used to support older people discharged from hospital: the cost saving lies in the reduction of length of hospital stays. Mason et al (2012) refer to the potential for memory supporting technologies to support people with cognitive impairment: they highlight however that whilst some of these utilise existing established technologies such as telephones, others are expensive, and not yet mature for widespread use. Perakis et al (2009) describe ALADDIN, an electronic platform for supporting people with dementia at home: they assert that this has potential to delay entry to institutional care and therefore save money. Pilotto et al's (2011) three country study of the HOPE scheme which includes electronic monitoring, communication and rehabilitation tools interestingly raises the question of how much individuals might be prepared to pay for such a system, moving away from consideration of costs to the public purse. Riley-Doucet et al (2009) explore feasibility and effectiveness of a 'multisensory environment' in people's own homes. They find that, whilst the technology did make the people cared for calmer and more relaxed, it did not provide respite from caring, though it did reduce stress. This is another intervention described as having 'potential' but requiring further research.

Sorell and Draper (2012) confidently assert that telecare provides means of saving money in care delivery for people with dementia: this means they argue, that it will be readily adopted in the coming years. Their concern is to ensure that the ethics of care supported by technology are considered, and that providers need to exercise caution lest the introduction of technology increases isolation of older people with dementia. Like Pilotto et al (2011) they also raise the issue of how much people may be prepared to pay themselves for technological support.

Lack of evidence

Westphal et al's (2010) review of technologies aimed at supporting people with mental health problems in later life, including dementia, identifies cost effectiveness analysis as a key gap in the literature. Whilst in some areas, such as telepsychiatry, cost effectiveness studies have shown benefits of technology, in the area of dementia, there is no strong evidence.

Caregiver support

There is a significant literature on technological support for caregivers in the form of on-line support, from care staff or in mutual support groups. Much of this literature identifies benefits of these measures, and suggests that they can support carers to continue caring at home for longer periods, therefore delaying admission to institutional care and in some cases reducing other calls on services such as GPs and hospitals. In this area, the evidence base is relatively strong. A systematic review and meta-analysis of ICT support systems for carers of people with dementia (Powell et al 2008) identified 'moderate effects' on carer stress across five good quality, rigorous studies. They conclude that better supported carers will be able to care longer at home, and that therefore entry to institutional care for people with dementia can be delayed. In a subsequent study however, (Powell et al 2010), they sought the views of carers about the technologies and found that whilst they saw potential benefits of the technologies, their cost was a particular concern, and carers were worried that the technologies might not work well.

Other included studies tend to confirm the efficacy of various kinds of caregiver support. Chiu et al's (2009) study of an on-line support system for Chinese Canadian carers found that the system was effective, though the authors note explicitly that they had not examined costs in detail. Davis et al (2011) studied a telephone based support system for carers following the admission of their relative to a care home: as compared with face to face support, they suggest this may provide a cost effective alternative. Marziali and Garcia's (2011) study compared an online carers support facility without video to one with video. They found that the video version produced particularly positive results in terms of self –efficacy, reduced stress and improved mental health. Furthermore, they established that the facility could be continued as a self help group at no cost to service providers. In terms of the set-up costs of delivering the service, the staff time involved was not different from that involved in face to face provision. For carers, there were considerable advantages, in that people who were unable to attend for face to face services could access support from their homes. In the longer term, the continuation of the support should, the authors argue, enable carers to continue with their work, at a saving of costs to formal services. Van Mierlo et al (2012) evaluated a telephone support system for carers. They found this to be effective in that carers reported less 'burden' after using the system.

In a study which produced less positive results, Rowe et al (2010) studied the impact of a night-time electronic monitoring system designed to support caregivers of people with dementia. They found that subjectively, carers reported benefits from the system, but that statistical analysis of objective indicators of sleep quality showed no significant improvement.

Most of the studies do not provide detailed data on costs. An exception is Wray et al (2010) who, in a high quality RCT, quantify cost benefits of a telephone delivered support and education system for carers. After six months, they calculate a statistically significant cost saving of $2768, but this was not maintained after one year. The main saving was related to care home costs not incurred.

Devices for quality of life and well being

Improved quality of life for people with dementia is frequently mentioned as a desirable benefit that assistive technology may confer. In this section, we consider literature examining technologies aimed specifically at supporting quality of life.

Enjoyment, interaction and communication

Some examples focus on devices that can promote enjoyment of life. Alm et al (2009) developed cognitive support for people with dementia to provide communication support, entertainment and creative activity and demonstrated that the devices could be integrated into daily life and would improve quality of life. Orpwood et al (2010) note that people with dementia, because of their particular impairments, are often excluded from using devices which might enhance quality of life. The INDEPENDENT project, having ascertained from people with dementia and carers what they would most enjoy, developed several devices, most particularly a music player, designed to be easy to use for people with cognitive impairment.

Murphy et al (2010)'s 'Talking Mats' is a communication tool that uses a fabric mat and a series of cards to support people to express their views. They tested it with people with dementia and found that it was indeed effective in enabling them to express their views. They highlight the importance of ascertaining and respecting the perspectives of people with dementia themselves.

Van der Wardt et al (2012) review literature on the impact of technological interventions on cognitive abilities and well being and provide a cautionary note. They find that literature generally identifies positive effects of technology, but note a number of important limitations of studies, which have not studied well-being rigorously enough, and have not considered factors such as health, initial cognitive capacity, education and socio-economic factors.

GPS tracking devices, location and well-being

GPS tracking devices have been much researched, and there are a number of competing products available. They are intended to enable the location of a person with dementia to be ascertained, and thereby prevent risks arising from getting lost. Bantry-White and Montgomery (2012) and Landau et al (2010a, 2010b) suggest there may be an over-emphasis on these risks and their costs, at the expense of consideration of the autonomy of people with dementia. Faucounau et al (2009), though a low quality piece of research, did emphasise that the views of people with dementia needed to be considered in relation to these devices: their study suggested that the device they reviewed was too cumbersome and did not work properly in real home situations. Pot et al (2012) tested a further GPS device, suggesting it is promising for supporting people with early stage dementia in terms of facilitating more freedom to go out. Another device is tested by Sposaro et al (2010): theirs reduces costs by using clients own handheld devices (phones) or internet links rather than needing specific or additional connectivity.

In a care home setting, Wigg's (2010) study, though assessed as low quality, did identify that using electronic devices such as movement sensors can permit an approach to care that permits people with dementia to move about freely – the alternative approach being to perceive 'wandering' as problematic, and to lock doors in care facilities.

Advance care planning

Advance care planning (ACP) is promoted as a means by which the wishes of the person themselves can be respected at a time when they may no longer be able to express them. Thus it can be seen as a way of supporting the person's autonomy and respecting their views, thus linked with quality of life. Deep et al (2010) explored the use of videos in supporting people with dementia and their families to make ACP decisions, concluding that the videos serve to support people to make more informed decisions and plans.

Issues for staff

Engstrom et al (2009) highlight a cost that is seldom considered in the literature. They examine the reactions of staff to the introduction of an ICT support system of telecare for people with dementia. They found that members of staff were initially disempowered by the unfamiliar system and some issues regarding deficient operation, but that after a time, there were more benefits than costs. The cost of staff development needs to be factored in to any analysis of costs. Similarly Evans et al (2011) who evaluated one very sheltered housing tenant's experience of a monitoring and messaging system to support their care highlighted the need for staff to be fully trained in and understanding of the purpose and operation of the technology concerned. Qadri et al (2009) tested the use of PDAs for nurses to support clinical decision making, finding these to be both effective and cheaper than the alternative of consultations with doctors. Schikhof and Mulder (2008) developed and tested a night-time electronic monitoring system in a care home, which was designed to reduce staff workload during the night in the context of pressure on resources. The system was designed in consultation with the care home to ensure it met the identified needs, and the authors argue that this meant it worked more effectively: significantly, it was readily accepted and understood by the staff in the care home.

Other issues

In addition to the areas above which were discussed more widely in the included studies, a range of other issues were raised. We note these here, with the caveat that none of them included detailed costs analysis: they represent potential, but need further evidence.

Location/remote services

Barton et al (2011) consider the use of video-telemedicine for people with dementia in rural areas, noting that the considerable literature on telemedicine has tended to ignore people with dementia. They find that the technology is effective during neurological testing, and that it can therefore enable services to be delivered to people who would otherwise not have access to them. Although more research is needed, there is clear potential here to reduce costs in terms of travel time for medical staff, as well as for people with dementia themselves. Morgan et al's (2009) Canadian research[7] is also relevant here. Their system of remote consultation was able to speed up diagnosis for people with dementia, and ensured that treatment and support plans could be put in place much more rapidly, without the need for people to travel long distances for repeat consultations.

Diagnosis and detection

Cheng and Zhuang (2010) describe a device that monitors a person's patterns of movements at home – described in the literature more generally as lifestyle monitoring devices. They claim that collecting such data could be used to identify when a person might be developing cognitive

[7] Not included in the review but referred to here as suggestive evidence.

impairment, and that dementia could therefore be detected at an early stage. Their view is that early detection and diagnosis could potentially reduce healthcare costs, as well as facilitating effective support for people with dementia.

Conclusions

The literature shows a real dearth of rigorous costs analysis of assistive technology for people with dementia and their carers. Nevertheless, there are clear indications of cost effectiveness in many respects, albeit from indirect evidence.

It is widely reported that the costs of care at home are lower than the costs of institutional care. Informal carers make a very significant contribution to care at home, and few studies take into account the total social cost of care, including items such as the costs of carers being out of the labour market. However, it remains the case that if informal carers can support people with dementia at home for longer periods, needs for institutional forms of care including hospitals and care homes will be reduced and calls on the public purse also reduced. The evidence of effectiveness of carer support systems is positive, and directly in some cases and indirectly in others supports the cost-effectiveness of their use.

Care at home delivered by formal care services is also reported to be less expensive than institutional care. Assistive technologies that facilitate formal care at home, such as memory support systems, monitoring telehealth, and GPS systems show potential to support people with dementia to stay at home, and therefore may be cost effective. They may also substitute for formal care services, especially where there is informal care available. Several notes of caution need to be considered however: technology can promote further isolation of people already excluded from social interaction if it is a substitute for human contact; some technologies, especially those which offer surveillance and monitoring require sensitive evaluation of potential intrusiveness and threats to autonomy; some technologies have been designed without input from users and may reflect the needs of service providers rather than people with dementia; and attention needs to be paid to the possibility that cost saving in one area (e.g. health) simply shifts costs to another sector (e.g. social care or informal care).

Whole system technology use is not widespread. Where it has been extensively used and evaluated, it does show promising results, but the studies referred to here do not specifically focus on people with dementia.

References

Alm, N., Astell, A., Gowans, G., Dye, R., Ellis, M., Vaughan, P. and Riley, P.(2009) Lessons learned from developing cognitive support for communication, entertainment, and creativity for older people with dementia ,*Universal Access in Human-Computer Interaction: Addressing Diversity*, Pt I, Proceedings, 5614:195-201.

Al-Oraibi, S., Fordham, R., and Lambert, R. (2012) Impact and economic assessment of assistive technology in care homes in Norfolk, UK. *Journal of Assistive Technologies*, 6,3:192-201.

Armfield, N. R., Gray L. C., and Smith A. C. (2012) Clinical use of Skype: A review of the evidence base. *Journal of Telemedicine and Telecare*, 18,3:125-127.

Armstrong, N., Nugent, C., Moore, G, and Finlay, D. (2010) Using smartphones to address the needs of persons with Alzheimer's disease, Annals of Telecommunications-*Annales Des Telecommunications*, 65,9-10: 485-495.

Astell, A., Alm, N., Gowans, G., Ellis, M., Dye, R. and Vaughan, P. (2009) Involving older people with dementia and their carers in designing computer based support systems: some methodological considerations, *Universal Access in the Information Society*, 8,1:49-59.

Audit Scotland (2011) *A Review of Telehealth in Scotland*, Edinburgh: Audit Scotland.

Bantry White, E. and Montgomery, P. (2012) Electronic tracking for people with dementia: An exploratory study of the ethical issues experienced by carers in making decisions about usage, *Dementia*, (on-line pre-print), 1-17.

Barton C., Morris R., Rothlind J., and Yaffe K. (2011) Video-telemedicine in a memory disorders clinic: evaluation and management of rural elders with cognitive impairment, *Telemedicine and e-Health* 17,10:789-93.

Bharucha, A., Anand, V., Forlizzi, J., Dew, M., Reynolds, C., Stevens, S. and Wactlar, H. (2009) Intelligent assistive technology applications to dementia care: current capabilities, limitations, and future challenges, *American Journal of Geriatric Psychiatry*, 17,2:88-104.

Boger, J., Hoey, J., Fenton, K., Craig, T., and Mihailidis, A. (2010) Using actors to develop technologies for older adults with dementia: A pilot study, *Gerontechnology* 9,4: 450-463, International Society for Gerontechnology, Helsinki, Finland, Finland.

Bowes, .A M. and McColgan, G. M. (2006) *Smart Technology and Community Care for Older People: Innovation in West Lothian, Scotland* Edinburgh: Age Concern Scotland.

Buettner, L., Yu, F., and Burgener, S. (2010) Evidence Supporting Technology-Based Interventions for People with Early-Stage Alzheimer's Disease, *Journal of Gerontological Nursing*, 36,10:15-19.

Carswell, W., McCullagh, P., Augusto, J., Martin, S., Mulvenna, M., Zheng, H., Wang, H., Wallace, J., McSorley, K., Taylor, B. and Jeffers, W. (2009) A review of the role of assistive technology for people with dementia in the hours of darkness, *Technology and Health Care*, 17,4:281-304.

Chandra A and Skinner J S (2011) *Technology growth and expenditure growth in health care* Working Paper 16953, Cambridge Mass: National Bureau of Economic Research http://www.nber.org/papers/w16953 .

Cheng, H.T., and Zhuang, W. (2010) Bluetooth-enabled in-home patient monitoring system: early detection of Alzheimer's Disease, *Wireless Communications*, 17,1:74-79.

Chiu, T., Marziali, E., Colantonio, A., Carswell, A., Gruneir, M., Tang, M. and Eysenbach, G. (2009) Internet-based caregiver support for Chinese Canadians taking care of a family member with Alzheimer disease and related dementia, *Canadian Journal on Aging*, 28, 4:323-336.

Davis, J.D., Tremont, G., Bishop, D. S., and Fortinsky, R.H. (2011) A telephone-delivered psychosocial intervention improves dementia caregiver adjustment following nursing home placement, *International Journal of Geriatric Psychiatry*, 26: 380–387.

Deep, K., Hunter, A., Murphy K., and Volandes, A (2010) "It helps me see with my heart": How video informs patients' rationale for decisions about future care in advanced dementia, *Patient Education and Counselling,* 81,2:229-234.

Deshpande, A., Khoja, S., Lorca, J., McKibbon, A., Rizo, C. and Jadad, A.R. (2008) *Asynchronous Telehealth: Systematic Review of Analytic Studies and Environmental Scan of Relevant Initiatives*. Ottawa: Canadian Agency for Drugs and Technologies in Health.

Dewsbury, G. and Ballard, D. (2012) Is your home telecare aware? *Nursing & Residential Care*, 14,8:422-4.

Dunk, B. and Schuette, M. (2009) The use of assistive technologies to support people with dementia at home, *Journal of Care Services Management,* 4,1: 90-99.

Dutton, R. (2009) 'Extra care' housing and people with dementia: what do we know about what works regarding the built and social environment, and the provision of care and support? Housing and Dementia Research Consortium / Housing 21 Dementia Voice.

Engstrom, M., Lindqvist, R., Ljunggren, B. and Carlsson, M. (2009) Staff members' perceptions of a ICT support package in dementia care during the process of implementation, *Journal of Nursing Management*, 17, 7:781-789.

Evans, N., Carey-Smith, B., and Orpwood, R. (2011) Using smart technology in an enabling way: a review of using technology to support daily life for a tenant with moderate dementia, *British Journal of Occupational Therapy* 74,5:249-253.

Evans, N., Harris, N. and Kuppuswamy, A. (2011) A smarter future: technology to enhance an independent lifestyle for our future selves, *International Journal of Therapy and Rehabilitation*, 18,12:495-499.

Farmer, A., Gibson, O.J., Tarassenko, L. and Neil, A. (2005) A systematic review of telemedicine interventions to support blood glucose self-monitoring in diabetes. *Diabetic Med*icine 22,10:1372-8.

Faucounau, V., Riguet, M., Orvoen, G., Lacombe, A., Rialle, V., Extra, J. and Rigaud, A-S. (2009) Electronic tracking system and wandering in Alzheimer's disease: A case study, *Annals of Physical and Rehabilitation Medicine*, 52,7-8:579-587.

Henderson, C., Knapp, M., Fernandez, J-L., Beecham, J., Hirani, A.P., Cartwright, M., Rixon, L., Beynon, M., Rogers, A., Bower, P., Doll, H., Fitzpatrick, R., Steventon, A., Bardsley, M., Hendy, J. and Newman, S.P. (2013) Cost effectiveness of telehealth for patients with long term conditions (Whole System Demonstrator telehealth questionnaire study): nested economic evaluation in a pragmatic, cluster randomised controlled trial *British Medical Journal* 346:f1035.

Japan Local Government Centre (2009) *Technology in care for the aged in Japan: two case studies*, Japan Local Government Centre, http://www.jlgc.org.uk/en/publicationsfromjapan.html (accessed 31st March 2013).

Jensen, L., Mansson, I., Holthe, T., Hurnasti, T. and Guonadottir, P. (2009) How assistive technology support cognitive disability, secure active living for persons with dementia and enhance new interfaces between formal and informal care in the area of dementia. *Assistive Technology from Adapted Equipment to Inclusive Environments*, 25, 222-227.

Kerr, D, Cunningham, C and Martin, S. (2010) *Telecare and Dementia: using telecare effectively in the support of people with dementia* Stirling: Dementia Services Development Centre and Joint Improvement Team, Scottich Government.

Khattak,A. M., Truc,P. T. H., Hung,L. X., Vinh,L. T., Dang,V., Guan,D., Pervez,Z., Han,M., Lee,S. and Lee,Y. (2011) Towards Smart Homes Using Low Level Sensory Data Sensors 11, 11581-11604; doi:10.3390/s111211581

Kinder, T. (2010) Social innovation in services: technologically assisted new care models for people with dementia and their usability, *International Journal Technology Management*, 51,1:106-120.

Lancioni, G, E., Perilli, V., Singh, N, N.,O'Reily, M. F., Sigafoos, J., Cassano, G., Pinto, K., Minervini, M. G. and Oliva, D. (2011) Technology-aided pictorial cues to support the performance of daily activities by persons with moderate Alzheimer's disease, *Research in Developmental Disabilities*, 33,1:265–273.

Lancioni, G.,Perilli, V,. O'Reilly, M, F., Singh, N, N., Sigafoos, J., Bosco, A., Caffo, A, O., Picucci, L., Cassano, G. and Joeneweg, J., (2013) Technology-based orientation programs to support indoor travel by persons with moderate Alzheimer's disease: Impact assessment and social validation, *Research in Developmental Disabilities*, 34,1:286–293.

Lancioni, G.E., La Martire, M.L., Singh,N.N., O'Reilly, M.F. Sigafoos, J., Pinto, K., and Minervini, M.G. (2008) Persons with mild or moderate Alzheimer's disease managing daily activities via verbal instruction technology, *American Journal of Alzheimers Disease and Other Dementias*, 23,6:552-562.

Landau, R., Auslander, G., Werner, S., Shoval, N. and Heinik, J. (2010a) Families' and professional caregivers' views of using advanced technology to track people with dementia, *Qualitative Health Research*, 20,3: 409-419.

Landau, R., Werner, S., Auslander, G, Shoval, N. and Heinik, J. (2010b) What do cognitively intact older people think about the use of electronic tracking devices for people with dementia? A preliminary analysis, *International Psychogeriatrics*, 22, 8:1301-1309.

Mann, W. C. and de Mallo M. A. F. (2010), Assistive technology use by the elderly in Brazil and the United States, *Topics in Geriatric Rehabilitation,* 26, 1:62-69.

Mapundu, Z., Simonnet, T., and Van Der Walt, J.S. (2012) A Videoconferencing Tool Acting as a Home-Based Healthcare Monitoring Robot for Elderly Patients, *Studies in Health Technology and Informatics*, 182:180-188.

Martin, S., Kelly, G., Kernohan, W.G., McCreight, B. and Nugent, C. (2008) Smart home technologies for health and social care support, *Cochrane Database of SystematicReviews*,2008, 4.

Marziali, E. and Garcia,L. J. (2011) Dementia caregivers' responses to 2 internet-based intervention programs, *American Journal of Alzheimers Disease and Other Dementias*, 26 ,1:36-43**.**

Mason, S., Craig, D., O'Neill, S., Donnelly, M. and Nugent, C. (2012) Electronic reminding technology for cognitive impairment, *British Journal of Nursing*, 20,14:855-861.

McCullagh, P.J., Carswell, W., Mulvenna, M., Augusto, J.C., Zheng, H. and Jeffers, P. (2011) Nocturnal sensing and intervention for assisted living of people with dementia. In: Lai, D., Begg, P. and Palaniswami, M. (Eds.) *Healthcare Sensor Networks: Challenges Toward Practical Implementation*. CRC Press Taylor & Francis Group, Florida, USA, pp. 283-303.

Mihailidis, A., Boger, J., Craig, T. and Hoey, J. (2008) The COACH prompting system to assist older adults with dementia through handwashing: An efficacy study, *BMC Geriatrics*, 8, 28.

Morgan, D., Crossley, M., Kirk, A., D'Arcy, C., Stewart, N., Biem, J., Forbes, D., Harder, S., Basran, J., Dal Bello-Haas, V. and McBain, L. (2009) Improving access to dementia care: development and evaluation of a rural and remote memory clinic, aging & mental health, *Aging & Mental Health* 13, 1: 17–30.

Murphy, J., Gray, C., Van Achterberg, T., Wyke, S. and Cox, S. (2010) The effectiveness of the Talking Mats framework in helping people with dementia to express their views on well-being , *Dementia: The International Journal of Social Research and Practice*, 9,4:454-472.

O'Neill, S.A., Parente,G., Donnelly, M. P., Nugent,C. D., Beattie, M. P., McClean, S.I., Scotney, B.W., Mason, S.C. and Craig,D. (2011) Assessing task compliance following mobile phone-based video reminders, *Conf Proc IEEE Eng Med Biol Soc*, 5295-5298, IEEE Service Center, United States.

Orpwood, R., Chadd, J., Howcroft, D., Sixsmith, A., Torrington, J., Gibson, G. and Chalfont, G. (2010) Designing technology to improve quality of life for people with dementia: user-led approaches, *Universal Access in the Information Society,* 9,3:249-259.

Perakis, K., Haritou, M. and Koutsouris, D. (2009) ALADDIN, a technology platform for the assisted living of dementia elderly individuals and their carers, *Distributed Computing, Artificial Intelligence, Bioinformatics, Soft Computing, and Ambient Assisted Living, Pt Ii, Proceedings*, 5518, 878-881.

Pilotto,A., D'Onofrio, G.,Benelli, E., Zanesco, A., Cabello, A., Margelí, M. C., Wanche-Politis, S., Seferis, K., Sancarlo, D. and Kilias,D. (2011) Information and communication technology systems to improve quality of life and safety of Alzheimer's disease patients: A multicenter international survey, *Journal of Alzheimers Disease*, 23,1:131-141.

Pot, A.M, Willemsea, B.M. and Horjusa, S. (2012) A pilot study on the use of tracking technology: Feasibility, acceptability, and benefits for people in early stages of dementia and their informal caregivers, *Aging & Mental Health* 16,1:127–134.

Powell, J., Chiu, T. and Eysenbach, G. (2008) A systematic review of networked technologies supporting carers of people with dementia, *Journal of Telemedicine and Telecare*, 14, 154-156.

Powell, J., Gunn, L., Lowe, P., Sheehan, B., Griffiths, F. and Clarke, A. (2010) New networked technologies and carers of people with dementia: an interview study, *Ageing & Society* 30,6:1073-1088.

Qadri, S., Wang, J., Ruiz, J. and Roos, B. (2009) Personal digital assistants as point-of-care tools in long-term care facilities: a pilot study, *Educational Gerontology*, 35:294-304.

Riikonen, M., Makela, K. and Perala, S. (2010) Safety and monitoring technologies for the homes of people with dementia, *Gerontechnology*, 9, 1:32-45.

Riley-Doucet, C. (2009) Use of multisensory environments in the home for people with dementia, *Journal of Gerontological Nursing*, 35, 5:43-52.

Robinson, L., Brittain, K., Lindsay, S., Jackson, D. and Olivier, P. (2009) Keeping In Touch Everyday (KITE) project: developing assistive technologies with people with dementia and their carers to promote independence, *International Psychogeriatrics*, 21, 3:494—502.

Rojas, S.V. and Gagnon, M.P. (2008) A systematic review of the key indicators for assessing telehomecare cost-effectiveness. *Telemed and E Health*. 14,9:896-904.

Rowe, M. A., Kairalla, J. A. and McCrae, C. S. (2010) Sleep in dementia caregivers and the effect of a nighttime monitoring system, *Journal of Nursing Scholarship*, 42, 3:338-347.

Schikhof, Y. and Mulder, I. (2008) Under watch and ward at night: design and evaluation of a remote monitoring system for dementia care, *Hci and Usability for Education and Work, Proceedings*, 5298, 475-486.

Schikhof, Y., Mulder, I. and Choenni, S. (2010) Who will watch (over) me? Humane monitoring in dementia care, *International Journal of Human-Computer Studies*, 68, 6:410-422.

Scottish Government (2010) *Shared vocabulary* available at http://www.scotland.gov.uk/Topics/Health/care/EandA/vocab (accessed 24th August 2012).

Scottish Government (2012) *A National Telehealth and Telecare Delivery Plan for Scotland to 2015* Edinburgh: Scottish Government

Sorell, T. and Draper, H. (2012) Telecare, surveillance, and the welfare state, *The American Journal of Bioethics*, 12,9: 36–44.

Sposaro, F., Danielson, J. and Tyson, G. (2010) iWander: an android application for dementia patients *Conf Proc IEEE Eng Med Biol Soc, 2010,* 3875-3878, IEEE Service Center, United States.

Steventon, A., Bardsley, M., Billings, J., Dixon, J., Doll, H., Hirani, S., Cartwright, M., Rixon, L., Knapp, M., Henderson, C., Rogers, A., Fitzpatrick, R., Hendy, J. and Newman, S. (2012) Effect of Telehealth on use of secondary care and mortality: findings from the Whole System Demonstrator cluster randomised trial' *British Medical Journal* 344:e3874.

van der Wardt, V., Bandelow, S. and Hogervorst, E. (2012) The relationship between cognitive abilities, wellbeing and use of new technologies in older people, *Gerontechnology*, 10, 4:187-200.

van Mierlo, L.D. Meiland, F.J. M., and Dröes, R. (2012) Dementelcoach: effect of telephone coaching on carers of community-dwelling people with dementia, *International Psychogeriatrics* , 24:2:212–222.

Westphal, A., Dingjan, P. and Attoe, R. (2010) What can low and high technologies do for late-life mental disorders? *Current Opinion in Psychiatry*, 23, 510-515.

Wigg, J.M. (2010) Liberating the wanderers: using technology to unlock doors for those living with dementia. *Sociology of Health and Illness*, 32,2:288-303.

Wray, L., Shulan, M., Toseland, R., Freeman, K., Vasquez, B. and Gao, J. (2010) The effect of telephone support groups on costs of care for veterans with dementia, *The Gerontologist*, 50, 5:623-631.

Appendices

Appendix One: Search terms and literature identified

Systematic searches were conducted of the databases shown in Table 16, with the searches indicated in table 17. In addition, CARDI Projects were browsed to identify relevant literature – the decision to browse all CARDI publications was made because it was not possible to do BOOLEAN searches on the database. Only 2 relevant publications were identified following the search of the CARDI projects. Table 18 provides a summary of the number of results from each of the searches. After duplicates were removed across different databases and within each of the databases searched, there were a total of 3590 articles. These were screened for relevance on bases of the title and abstract. A total of 194 were seen as potentially appropriate for full review after this process. Of these, 103 were published in the last 5 years, and a further 62 published in the last 10 years. Given the number of articles, and the time set aside for review, a decision was made to prioritise articles published within the last five years for full review. A total of 103 items were assigned to a team of reviewers for full review. Reviewers were asked to omit books, conference proceedings and thesis at this stage as these are less likely to be peer reviewed: 21 of these were excluded at this stage. 82 items underwent full text review. A further 23 were excluded at this stage as not relevant, leaving 59 included items. Figure 1 provides a flow chart of the selection process.

Table 16: Databases searched

CINAHL
CSA Illumina (ASSIA + Social Services Abstracts + Sociological Abstracts databases)
IngentaConnect
OVID (PsychINFO + Medline + Cochrane Library)
Web of Science (via Web of Knowledge)
Social Care Online
Campbell library

Table 17: Search Terms

(dementia OR Alzheimer*) and (technolog* or tool* or aid*) and (cost* or price)
(dementia OR Alzheimer*) and (technolog* or tool* or aid*) and (economic or financ*)
(dementia OR Alzheimer*)and (technolog* or tool* or aid*) and (effectiv*)
(dementia OR Alzheimer*) and (technolog* or tool* or aid*) and (minimi* or reduc*)
(dementia OR Alzheimer*) and (technolog* or tool* or aid*) and (value or benefit)
(dementia OR Alzheimer*) and (tele*) and (cost* or price)
(dementia OR Alzheimer*)and (tele*) and (economic or financ*)
(dementia OR Alzheimer*) and (tele*) and effectiv*
(dementia OR Alzheimer*) and (tele*) and (minimi* or reduc*)
(dementia OR Alzheimer*) and (tele*) and (value or benefit)
(dementia OR Alzheimer*) and (environment* control* or monitor) and (cost* or price)
(dementia OR Alzheimer*) and (environment* control* or monitor) and (economic or financ*
(dementia OR Alzheimer*) and (environment* control* or monitor) and effectiv*

(dementia OR Alzheimer*) and (environment* control* or monitor) and (minimi* or reduc*)
(dementia OR Alzheimer*) and (environment* control* or monitor) and (value or benefit)

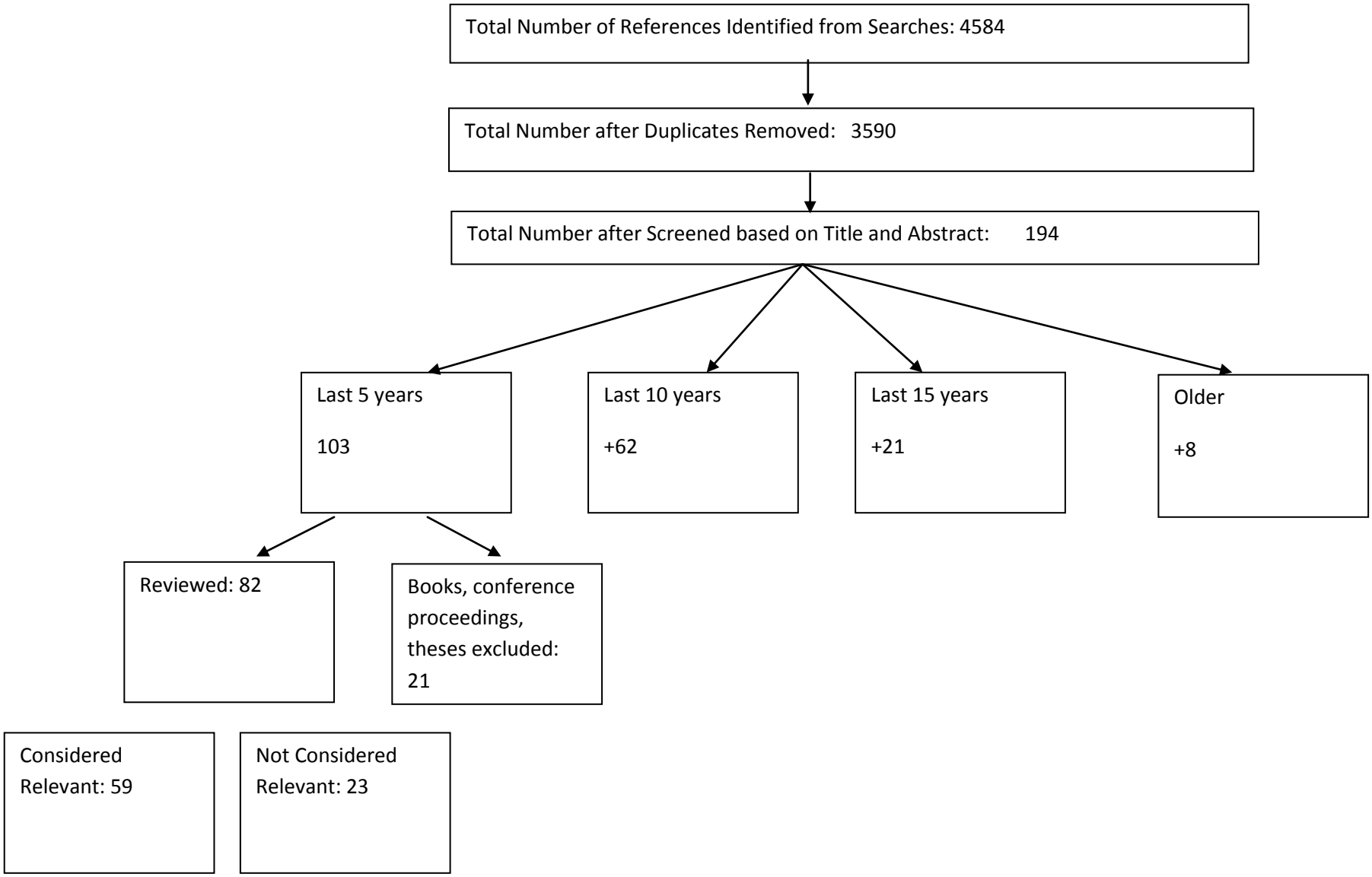
Table 18: Results of searches from each database

	CINAHL	CSA Illumina (ASSIA + Social Services Abstracts + Sociological Abstracts databases)	IngentaConnect	OVID (PsychINFO + Medline + Cochrane Library)	Web of Knowledge DorA in title, others in topic	Social Care Online	Campbell library
(dementia OR Alzheimer*) and (technolog* or tool* or aid*) and (cost* or price)	58	30	8	180	194	58	0
(dementia OR Alzheimer*) and (technolog* or tool* or aid*) and (economic or financ*)	36	16	8	150	256	26	0
(dementia OR Alzheimer*)and (technolog* or tool* or aid*) and (effectiv*)	154	84	0	180	494	94	0
(dementia OR Alzheimer*) and (technolog* or tool* or aid*) and (minimi* or reduc*)	116	59	8	150	684	53	0
(dementia OR Alzheimer*) and (technolog* or tool* or aid*) and (value or benefit)	90	78	8	150	803	36	0
(dementia OR Alzheimer*) and (tele*) and (cost* or price)	15	21	1	30	43	20	0
(dementia OR Alzheimer*)and (tele*) and (economic or financ*)	9	10	1	25	23	5	0
(dementia OR Alzheimer*) and (tele*) and effectiv*	41	28	0	53	55	25	0
(dementia OR Alzheimer*) and (tele*) and (minimi* or reduc*)	42	39	1	68	76	11	0
(dementia OR Alzheimer*) and (tele*) and (value or	17	38	1	57	83	12	

benefit)							
(dementia OR Alzheimer*) and (environment* control* or monitor) and (cost* or price)	5	5	0	35	78	5	0
(dementia OR Alzheimer*) and (environment* control* or monitor) and (economic or financ*	4	4	0	40	33	2	0
(dementia OR Alzheimer*) and (environment* control* or monitor) and effectiv*	11	30	0	40	280	18	0
(dementia OR Alzheimer*) and (environment* control* or monitor) and (minimi* or reduc*)	19	35	0	88	445	17	0
(dementia OR Alzheimer*) and (environment* control* or monitor) and (value or benefit)	6	30	0	61	363	4	0
TOTAL NUMBER OF REFERENCES	623	507	36	1307	3910	386	0
DUPLICATES REMOVED	270	164	27	442	1108	178	0
TOTAL NUMBER AFTER DUPLICATES REMOVED	353	343	9	865	2802	208	0

TOTAL ACROSS SEARCHES	**4582 and 2 CARDI project**
DUPLICATES REMOVED ACROSS SEARCHES	802
TOTAL FOR REVIEW	3590

Figure 1: Diagram summarising stages of search process



Appendix Two: Table of quality assessment results

PICO Table for evaluated publications

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Alm, N., Astell, A., Gowans, G., Dye, R., Ellis, M., Vaughan, P. and Riley, P. (2009)	Other - Product description	Not applicable	Not applicable	Not applicable	[Publication describes cognitive supports for people with dementia developed in three areas of activity : communication, entertainment and creativity]	Medium
Al-Oraibi, S., Fordham, R. and Lambert, R. (2012)	Economic evaluation	People aged between 50 and 99 residing in two care homes, one for people with dementia (n=32) and one providing rehabilitation and	The introduction of a new assistive technology system in the homes	Periods before and after installation (10 months for home 1 and 6 months for home 2)	The incidence and nature of (incident reports over a defined period)	Low

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
		intermediate care places in addition to having a dementia unit (n=48, maximum)				
Armfield, N. R., Gray L. C. and Smith A. C. (2012)	(Systematic) Literature review	Multiple studies examined with varying populations	Multiple interventions		The clinical use of Skype, a popular and free software application that allows PCs and mobile devices to be used for video communication over the Internet.	Medium
Armstrong, N., Nugent, C., Moore, G. and Finlay, D. (2010)	Other – Selective review	Multiple studies examined with varying populations	Multiple interventions		The use of mobile technology and specifically smartphones in meeting the needs of people with Alzheimer's disease.	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Astell, A., Alm, N., Gowans, G., Ellis, M., Dye, R. and Vaughan, P. (2009)	Other - Description of a long-term project	People with dementia and caregivers in a range of settings (n=not given)	Use of the Computer Interactive Reminiscence and Conversation Aid (CIRCA) to prompt and facilitate conversation	Use of standard reminiscence materials to prompt and facilitate conversation	Engagement and enjoyment (observed verbal and non-verbal behaviours during interactions, post-use semi-structured interviews)	High
Bantry White, E. and Montgomery, P. (2012)	Qualitative study	Familial, informal carers of people with dementia living in a domestic setting who were using GPS tracking technology (n=10)	Use of a GPS device which enabled the location of the person with dementia to be tracked	None	Carers' decision-making processes; involvement of the person with dementia in the decision-making process; ethical dilemmas faced by carers in using GPS devices (interviews)	Medium
Barton, C., Morris, R., Rothlind, J. and	Other - Experimental study	US army veterans aged between 71 and 88 who required evaluation for	Use of video-telemedicine (VTM) equipment at a local clinic to remotely	None	Feasibility of use of VTM for remote cognitive evaluations	Medium

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Yaffe, K. (2011)		cognitive complaints and who were unable to travel for in-person evaluation, had no significant visual or auditory impairments, had a knowledgeable caregiver, and were cognitively able to participate in a video evaluation (n=15)	receive cognitive evaluations from a specialty cognitive disorders clinic		(observation)	
Bharucha, A., Anand, V., Forlizzi, J., Dew, M., Reynolds, C., Stevens, S. and Wactlar, H. (2009)	(Systematic) Literature Review	Multiple studies examined with varying populations	Multiple interventions		Identifying the range of technologies with potential application to dementia care	Medium
Boger, J., Hoey, J., Fenton, K., Craig, T. and Mihailidis, A.	Other - A-B-A-B Single Subject research	Professional caregivers (n=11)	Viewing and evaluation of video segments of actors simulating older	Viewing and evaluation of video segments of older people with	Believability of actors (rating of whether behaviour seen was like that of a person	Medium

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
(2010)	design		people with dementia engaged in carer guided and AT guided hand-washing activity	dementia engaged in carer guided and AT guided hand-washing activity	with dementia; identification of video clips as showing actor or person with dementia; self-rating of certainty of identifications)	
Buettner, L., Yu, F., & Burgener, S. (2010)	(Systematic) Literature Review	Multiple studies examined with varying populations	Multiple interventions		The use of different technologies to improve care and quality of life for people with Alzheimer's disease and their families	Medium
Carswell, W., McCullagh, P., Augusto, J., Martin, S., Mulvenna, M., Zheng, H., Wang, H., Wallace, J.,	(Systematic) Literature Review	Multiple studies examined with varying populations	Multiple interventions		Examining assistive technology for people with dementia for use in the hours of darkness; or studies of assistive	Low

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
McSorley, K., Taylor, B. and Jeffers, W. (2009)					technologies used in the hours of daylight that could have uses in hours of darkness.	
Cheng, H.T. and Zhuang, W. (2010)	Other - Feasibility study and methodology introduction	Not applicable - article describes a proposed study	(Proposed) Use of a Bluetooth-enabled in-home patient monitoring system to identify patterns of movement	None	(Proposed) Early signalling of possible Alzheimer's disease (analysis of patterns of movement within the home)	Medium
Chiu, T., Marziali, E., Colantonio, A., Carswell, A., Gruneir, M., Tang, M. and Eysenbach, G. (2009)	Qualitative Study	Chinese-speaking internet-enabled adult family caregivers of people with dementia living in the community (n=28)	Provision of an Internet-based Caregiver Support Service (ICSS) providing an information web site and personalised email access to a clinician	Pre- versus post-intervention	Change in perceived caregiver burden (Chinese-language version of the 28-item Burden Scale for Family Caregivers (BSFC))	High
Davis, J.D.,	Randomised	Caregivers who had	Three-month	Non-contact	Adjustment to the	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Tremont, G., Bishop, D. S., and Fortinsky, R.H. (2011)	Controlled Trial (RCT)	been providing more than four hours of care a day for at least six months to people with dementia who had recently been admitted to care homes (n=46, average age =57.25)	intervention consisting of ten contacts: assessment, followed by programme of 7 weekly telephone sessions with psychologists designed to facilitate adaptation through reappraisal and coping, plus two bi-monthly review and reinforcement sessions	control group with access to standard care	different caregiver burden associated with the person cared for moving into a residential care home (46-item Caregiver Guilt Questionnaire for Nursing Home Placement; 20-item Center for Epidemiology Studies Depression Scale; 22-item Zarit et al Burden Interview (ZBI); 29-item Nursing Home Hassles Scale; 62-item Ohio Department of Aging Family Satisfaction Instrument)	

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Deep, K., Hunter, A., Murphy, K. and Volandes, A. (2010)	Other - Mixed methods using questionnaires and visual methods	People aged 40 or older without limited decision-making capacity who had no prior relationship with someone with advanced dementia or older and who had appointments to attend 7 primary care clinics in Boston, Massachusetts (n= 83 women, 37 men)	Viewing a two-minute video of a female depicting salient function-related features of advanced dementia	Listening to a verbal description of advanced dementia detailing the functional impairments associated with this condition	Personal preferences as to future levels of care ('life-prolonging', 'limited' or 'comfort') in the event of advanced dementia and reasons for preference (structured verbal questionnaire)	High
Dewsbury, G. and Ballard, D. (2012)	Other - Descriptive commentary	None	None	None	[Publication is general discussion of use of technology to support carers and people with cognitive impairment in care homes]	Low
Dunk, B. and	Other -	People with dementia living in two London	Use of different assistive technologies	None	Not applicable - purpose of	Low

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Schuette, M. (2009)	Account of personal experience	boroughs (no detail provided)	for people with dementia		publication is to share practical experiences of authors with health, social services, primary care trust and voluntary sector colleagues.	
Dutton, R. (2009)	(Systematic) Literature Review	Multiple studies examined with varying populations	Multiple interventions		The use of assistive technologies the specific setting of extra care housing	Medium
Engstrom, M., Lindqvist, R., Ljunggren, B. and Carlsson, M. (2009)	Qualitative Study	Female members of staff working in three units of a residential home for people with dementia where new ICT support packages were implemented (n=14)	Deployment of a new ICT support system including: new monitoring and alarm systems; an entirely new email and Internet system; and email facility providing support to residents'	Before, during and after ICT system implementation	Staff members' perceptions of an ICT support package during the process of implementation (group interviews at four different time points)	Medium

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
			relatives.			
Evans, N., Harris, N. and Kuppuswamy, A. (2011)	Other - Overview plus commentary on telecare for people with dementia	Not applicable	Various		[Publication provides brief overview of use of telecare for people with dementia]	Medium
Evans,N., Carey-Smith, B. and Orpwood, R. (2011)	Other - Case study	A woman aged 85 with mild to moderate dementia (n=1)	Residence in a flat equipped with enabling smart technology (EST) incorporating data monitoring/alerts, direct environmental controls, and an integrated system of individualised recorded messages for a period of 12 months.	Period in residence before technology switched on.	Effectiveness of assistive technology provision in meeting four agreed goals contributing to in-home health and safety (Individually Prioritised Problem Assessment (IPPA), DEMQOL instrument for measuring quality of life of people with dementia)	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Faucounau, V., Riguet, M., Orvoen, G., Lacombe, A., Rialle, V., Extra, J. and Rigaud, A-S. (2009)	Qualitative Study	A male aged 84 with dementia and his female spousal caregiver aged 68 (n=2)	Deployment of an electronic tracking device incorporating GPS receiver and mobile phone for a period of 1 month	Before, during and after deployment	Device acceptability and usability (interviews)	Low
Japan Local Government Centre (2009)	Other - Description of two technologies	None	None	None	[Publication describes home videophone and call centre and therapeutic robotic seal (Paro)]	Low
Jensen, L., Mansson, I., Holthe, T., Hurnasti, T. and Guonadottir, P. (2009)	Qualitative Study	Assistive technology users with dementia (n=27, 19 females with average age 76.7, 8 males with average age 68)	Use of a range of assistive devices	None	Use of cognitive assistive devices and key factors in the process of delivering assistive devices to people with dementia	Low

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
					(interviews)	
Khattak,A. M., Truc,P. T. H., Hung,L. X., Vinh,L. T., Dang,V., Guan,D., Pervez,Z., Han,M., Lee,S. and Lee,Y. (2011)	Other – Case study	One person used to demonstrate the Human Activity Recognition Engine (HARE) designed to recognise activities of daily living	None	None	Demonstration of Human Activity Recognition Engine (HARE) designed to recognise activities of daily living	Low
Kinder, T. (2010)	Other – Case study	Senior figures associated with shaping care services for the elderly in West Lothian (n=4) and front-line social workers and practice managers working in smart housing (n=16)	Semi-structured interview		Analysis of local service social innovation (interviews, participant observation)	Medium
Lancioni,G.E., La Martire, M.L., Singh, N.N.,	Other - Multiple	Four studies described. Studies 1-3, populations all female	Study 1: Performance of bathroom routine activity supported by	Baseline performance of activities without	Reduction of errors in carrying out activity expressed as a	Medium

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
O'Reilly, M.F. Sigafoos, J., Pinto, K., and Minervini, M.G. (2008)	Before and After studies	and all temporarily resident at an Alzheimer rehabilitation centre as follows: 1) n=4, aged 59-85, MMSE score 11-16 passive or erratic in some ADLs, 2) n=2, aged 81 and 88, MMSE score 11 and 14, passive or erratic in some ADLs, 3) n=3, aged 73-81, MMSE score 14-15, having difficulty with some ADLs. Study 4 involved 1 male former resident now living at home, aged 82, MMSE 19.	technology providing automated verbal instruction. Study 2: Performance of dining table setting activity supported by technology providing automated verbal instruction. Study 3: Performance of coffee-making activity supported by technology providing automated verbal instruction. Study 4: Performance of bathroom and dressing routine activities supported by technology providing automated verbal instruction.	technology-delivered cues	percentage of correct steps in given activity (observation)	

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Lancioni, G.E., Perilli, V., O'Reilly, M, F., Singh, N. N., Sigafoos, J., Bosco, A., Caffo, A. O., Picucci, L., Cassano, G. and Joeneweg, J. (2013)	Other - Before and After study	Ambulatory people with Alzheimer's disease and orientation difficulties, MMSE scores less than 15, attending a day centre (n=5, 4 female, 1 male, age range 72-80)	Carrying specified objects to a specified destination in a day centre with cues provided by a) verbal orientation technology or b) light emitting orientation technology	Baseline performance of activities without technology-delivered cues	Improvement in user orientation, as measured by change in percentage of correct travels during baseline and experimental conditions (observation)	Medium
Lancioni, G, E., Perilli, V., Singh, N, N., O'Reily, M. F., Sigafoos, J., Cassano, G., Pinto, K., Minervini, M. G. and Oliva, D. (2011)	Other - Before and After study	Females with Alzheimer's disease, MMSE scores 12-18, attending a day centre and participating in activities (n=3, age range 73-79)	Performance of four activities with cues delivered by automated technologies, either a) pictorial cues, b) verbal instruction or c) pictorial cues and verbal instruction.	Baseline performance of activities without technology-delivered cues	Reduction of errors in carrying out activity, expressed as a percentage of correct steps in given activity (observation)	Medium
Landau, R., Auslander, G., Werner, S.,	Qualitative Study	Experienced group facilitators of the Israel Alzheimer's	Focus groups (n=4) around a vignette designed to prompt	None	Families' and professional caregivers' views of	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Shoval, N. and Heinik, J. (2010a)		Society (n=20); health, social care and other professionals who were members of a team of a psychogeriatric center in Israel (n=12); spouse and adult children caregivers who were participating in support groups organized by the Israel Alzheimer's Society (n=36, approx 24 female)	discussion of electronic tracking of persons with dementia using GPS systems		using advanced technology to track people with dementia (focus group discussion)	
Landau, R., Werner, S., Auslander,G, Shoval N. and Heinik, J. (2010b)	Other - Mixed methods using questionnaire and focus	Independent, socially active and cognitively intact individuals aged 65 or over (questionnaire n=42, 29 female and 13	Questionnaire and focus groups		The attitudes of cognitively intact older people toward the use of tracking devices for people with dementia	

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
	groups	male, living in the community; focus groups n=23, 15 female and 8 male, living in two different retirement homes)			(questionnaire and focus groups)	
Mann W. C. and de Mello M. A. F. (2010)	(Systematic) Literature Review	Multiple studies examined with varying populations	Multiple interventions		The use of assistive technologies by older people in Brazil and America	Medium
Mapundu, Z.,Simonnet, T., and Van Der Walt, J.S. (2012)	Other – Discussion document	None	None	None	[Publication is a technical discussion of videoconferencing system architecture and infrastructure]	Low
Marziali,E. and Garcia,L. J. (2011)	Other - Before and After study	Dementia caregivers, spousal, or adult children who lived with the care recipient located in three different cities in	Two interventions, both Internet-based clinical support intervention programs designed to allow caregivers to share	Pre- versus post-intervention	Impact of intervention on dementia caregivers' experienced stress and health status (Health Status	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
		Canada (n=91)	their thoughts, feelings and experiences which included access to a caregiver information handbook. The first (n=40) was a text-based chat group with access to 6 videos on managing caregiving tasks; the second (n=52) incorporated online support group video conferencing facilitated by a clinician.		Questionnaire (HSQ 12), Center for Epidemiologic Studies Depression Scale (CES-D), modified version of the Functional Autonomy Measurement System (SMAF), Revised Scale for Caregiver Self-efficacy, Multidimensional Scale of Perceived Social Support, interviews.	
Mason, S., Craig, D., O'Neill, S., Donnelly, M. and Nugent, C. (2012)	(Systematic) Literature Review	Multiple studies examined with varying populations	Multiple interventions		Employing electronic reminding technology to support individuals with cognitive	Medium

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
					impairment	
McCullagh, P.J., Carswell, W., Mulvenna, M., Augusto, J.C., Zheng, H. and Jeffers, P. (2011)	Other – Descriptive commentary	None	None	None	[Publication describes and reflects on NOCTURNAL (Night Optimised Care Technology for UseRs Needing Assistive Lifestyles) project]	Low
Mihailidis, A., Boger, J., Craig, T., and Hoey, J. (2008)	Other - Single Subject Research Design (A-B-A-B)	Residents aged over 65 with moderate-to-severe dementia living in a long-term care facility in Toronto with fluency in English, no history of violence, no severe motor impairments and normal hearing (n=6, 5 female, 1 male. Age range 73-92).	Use of the COACH autonomous prompting system to assist older adults with dementia through hand-washing.	Hand-washing when COACH prompting system not used	Efficacy of the COACH system in: guiding people with dementia in hand-washing independently of caregiver; reducing caregiver workload in terms of frequency of interactions during hand-washing; and providing correct assistance	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
					throughout task (analysis of video of trials)	
Murphy, J., Gray, C., Van Achterberg, T., Wyke, S. and Cox, S. (2010)	Other - Mixed methods study	People with a confirmed diagnosis of dementia living in central Scotland whose first language was English and who had sufficient vision to see picture symbols and were physically well enough to take part (n=31, age range 54-90).	Interview using the Talking Mats communication framework incorporating sets of symbols on topics, options and a visual scale	1) Interview in the form of unstructured (ordinary) conversation; 2) Structured conversation with random topic order.	Communication effectiveness of people with dementia across the three test conditions along three axes: functional communication; perseveration (repetition of words, phrases or behaviours no longer relevant to conversation); and 'on-task behaviour' – i.e. percentage of time spent in on-task behaviours (authors' 'Effectiveness	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
					framework of functional communication', video footage)	
O'Neill, S., Parente, G., Donnelly, M., Nugent, C., Beattie, M., McClean, S., Scotney, B., Mason, S. and Craig, D. (2011)	Other - Non-randomised, non-controlled proof of principle study	Healthy employees and postgraduate students at the University of Ulster (n=10)	Daily reminders of five or more tasks delivery via the Mobile Phone Video Streaming (MPVS) system developed and evaluated by the research group	Not applicable	Compliance to reminders sent by video messages on a mobile phone (participants' written records of compliance, data from 'sensorised environment' incorporating a series of electronic contact sensors)	Medium
Orpwood, R., Chadd, J., Howcroft, D., Sixsmith, A., Torrington, J., Gibson, G. and	Other - Mixed methods multi-step	1) User survey: people in the early to moderate stages of dementia, living in their own homes (n=16) and in care	Not applicable - project developed prototypes of: a music player; a device to reduce social isolation; a conversation	Not applicable	Development of devices to support an improvement in the quality of life of people with	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Chalfont, G. (2010)	project	homes (n=10); 2) Multi-disciplinary workshops: project members covering the disciplines of social gerontology, engineering, and architecture (n=not specified); 3) Prototype testing: people with mild to moderate dementia living in the community in Bath (n=not specified)	prompter; and a device to support sequences of tasks.		dementia	
Perakis, K., Haritou, M. and Koutsouris, D. (2009)	Other - Description of a service	Not applicable	Not applicable	Not applicable	[Publication describes ALADDIN (A technology pLatform for the Assisted living of Dementia elDerly INdividuals and their carers) project]	Low

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Pilotto, A., D'Onofrio, G., Benelli,E., Zanesco,A., Cabello,A., Margelí, M. C., Wanche-Politis, S., Seferis, K., Sancarlo, D. and Kilias, D. (2011)	Other - Multicultural international survey	Relatives or caregivers of people with Alzheimer's disease aged 65 years or older with the ability to give informed consent or the availability of a proxy for informed consent living in Italy, Spain or Greece (n=223; 115 from Italy (M = 45, F = 70, mean age = 79.03±6.14 years), 85 from Spain (M = 42, F = 43, mean age = 78.19±7.49 years), and 23 from Greece (M = 8, F = 15, mean age = 81.30±6.89 years).	Watching a video on the technological devices and functions potentially provided by the Smart Home for Elderly People (HOPE) Project and completing a 13-item questionnaire	Not applicable	Relatives/caregivers perceptions of the potential utility and acceptability of ICT systems provided by the HOPE project (13-item HOPE questionnaire)	Medium
Pot, A.M, Willemse, B.M.	Other - Before and	Dyads in the Netherlands	Use of used a tracking device combining GPS	Before use and after 3 months'	Feasibility and acceptability of the	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
and Horjus, S. (2012)	After study	consisting of a person with a diagnosis of dementia living at home and with the ability to give informed consent to participate and their caregiver (n=33)	and General Packet Radio Service (GPRS) with functions allowing track and trace, caregiver calling by the wearer and wearer contact by caregiver using inbuilt loudspeaker for a period of three months.	use.	device, effect on caregivers (structured questions, scale based on the Night Time Activity Worry-Scale and the Self-Perceived Pressure from Informal Care (SPPIC) questionnaire)	
Powell J., Chiu T. and Eysenbach G. (2008)	(Systematic) Literature Review	Multiple studies examined with varying populations	Multiple interventions		Interventions including elements of networked peer support	High
Powell, J., Gunn, L., Lowe, P., Sheehan, B., Griffiths, F. and Clarke, A. (2010)	Qualitative Study	Informal carers living in the Midlands area of the UK who were caring for people at different stages of the progression of dementia (n=34, 22	Semi-structured interview based on five written vignettes illustrating applications of networked	Not applicable	Perspectives of carers of people with dementia about new networked technologies (interviews)	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
		female and 12 male, age range 23-91)	technologies			
Qadri, S., Wang, J., Ruiz, J. and Roos, B. (2009)	Qualitative Study	Nurses working at three differently sized nursing homes in Miami, Florida (n=25, 9 from larger home, 10 from medium-sized home, 6 from smaller home)	Use of an electronic PDA-based point-of-care decision support tool for one month.	Use of a card-based based point-of-care decision support tool for one month.	Feasibility, usability and utility of the point-of-care tools, (pre- and post-intervention questionnaire interviews, focus groups)	Medium
Riikonen, M., Makela, K. and Perala, S. (2010)	Economic Evaluation	People with dementia living at home in six communities in the Finnish Health District of South Ostrobothnia (n=25, age range 54-90) and their family caregivers.	Installation of a suite of technologies as determined by a detailed user needs appraisal for a period of time (until removed or intervention terminated, average = 7.5 months)	4 time points, including before, during and after intervention period.	Users' perceptions of the most appropriate technologies for home support; impact of intervention technologies on ability of recipient to remain living at home; effect of the use of technologies on the overall costs	Low

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
					of care (interviews, expert opinion, data on purchase, installation, training, maintenance and support costs and on-going costs of use of intervention technologies and average costs of institutional care)	
Riley-Doucet, C. (2009)	Qualitative Study	People living in the greater Michigan area aged 65 years or over with a diagnosis of dementia (n=10) and their primary caregivers aged 18 years and over.	Use of a portable Snoezelen kit installed in a room in the person with dementia's home for a three-week period.	Pre-, during, and post-intervention period	Perceived effect of multi-stimulatory environment (MSE) on person with dementia and relationship with caregiver and feasibility of using MSE as a home-based care modality	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
					(interviews)	
Robinson, L., Brittain, K., Lindsay, S., Jackson, D. and Olivier, P. (2009)	Qualitative Study	People with dementia (PwD) living in the community in the north of England and their carers plus support group volunteers (scoping focus groups, n=10 PwD, 11 carers, 4 Alzheimer's Society volunteers; participatory design workshops n=12 PwD, 10 carers; prototype testing n=2 PwD, 2 carers).	Scoping focus group; participatory design workshop; prototype testing	Not applicable	Creation of acceptable and effective prototype technologies to facilitate independence in people with dementia (focus groups, workshops, product testing)	High
Rowe, M. A., Kairalla, J. A., and McCrae, C. S. (2010)	Controlled Clinical Trial (CCT)	Primary caregivers aged 21 or older to people with dementia who had no additional night-time support,	Provision of a home monitoring system designed to reliably awaken a caregiver when the PWD left the	Before and after control group design with repeated measures at	Total sleep time and wake after sleep; sleep quality, measured by; caregiver worry-	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
		who expressed concerns about the level of night-time activity of the person cared for, who had no sleep disorders and who read and spoke English (n=49)	bed at night for a period of up to 1 year.	baseline and post-test months 2, 3, 4, 5, 6, 8, 10, and 12.	distress (actigraphy (analysis of wrist movement), participant self-report, study-specific 3-item scale for worry-distress)	
Schikhof, Y. and Mulder, I. (2008)	Other - Prototype development and evaluation	Residents, family members of residents and members of staff at a care home in Rotterdam (n=4 residents, 13 family members, 8 members of staff).	1) Informational meetings for family members and members of staff; 2) Testing of the prototype remote monitoring system with four residents in the selected ward during the evening and night shifts in a 4-week period.	1) Before and after intervention; 2) None	Family member and staff acceptance of camera surveillance in the bedrooms of residents with dementia; usability and effectiveness of the system in practice (survey questionnaire and interviews, self-complete questionnaire for relevant staff)	High

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Schikhof, Y., Mulder, I. and Choenni, S. (2010)	Other - Multi-step prototype design and pilot project	Experts in small-scale housing (n=3), together with nursing staff (n=5) and managers (n=5) of a care organisation engaged in building a small-scale housing development for people with dementia	Focus groups	None	Values perceived as important in the context of small-scale housing (focus groups for nursing staff, managers and experts respectively)	High
Sorell,T. and Draper, H. (2012)	Other - Discussion paper	None	Not applicable	Not applicable	[Publication is a discussion of ethical and political issues in use of telecare]	Medium
Sposaro, F., Danielson, J. and Tyson, G. (2010)	Other - Product description	None	Not applicable	Not applicable	[Publication presents iWander application for people with dementia, which runs on Android based devices with GPS and communication	High

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
					capabilities]	
van der Wardt, V., Bandelow, S. and Hogervorst, E. (2012)	(Systematic) Literature Review	Multiple studies examined with varying populations	Multiple interventions		The relationship between ICT use and cognitive abilities, in particular the direction of this relationship	Medium
van Mierlo, L.D. Meiland, F.J. M. and Dröes, R. (2012)	Controlled Before and After Study (CBA)	Informal caregivers of people with dementia living in the community in the regions of Amersfoort-Leusden, Utrecht, Amsterdam, and Laren and Huizen in The Netherlands (n=54; 47 female 7 male, average age 63.8 years)	1) A telephone coaching intervention with calls every 2-3 weeks from professional caregivers (10 calls over intervention period) , or 2) The same telephone coaching intervention plus respite care (psychogeriatric day care for the person with dementia)	Informal carers receiving only respite care (psychogeriatric day care for the person with dementia)	Sense of competence, experienced burden, and health complaints of informal caregivers (7-item Short Sense of Competence Scale (SSCQ), General Health Questionnaire (GHQ-28))	Medium

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Westphal, A., Dingjan, P. and Attoe, R. (2010)	(Systematic) Literature Review	Multiple studies examined with varying populations	Multiple interventions		The use of low and high technology in the areas of mood disorders, psychosis, normal ageing, mild cognitive impairment and dementia	Low
Wigg, J.M. (2010)	Qualitative Study	Residents with dementia living in a 30-person unit of a care home in north-eastern USA and residents in a smaller care home (maximum capacity 8 people) specialising in dementia care (n=not given)	None	None	Impact of wandering protections (e.g. locked doors, motion detectors) on residents quality of life (non-participant observation)	
Wray, L., Shulan, M., Toseland, R., Freeman, K., Vasquez, B. and	Randomised Controlled Trial (RCT)	Spousal caregivers of US veterans with diagnoses of dementia living in the	A 10-week group Telehealth Education Program (TEP) delivered by	Usual care - receiving all usual services	Healthcare cost and utilisation at baseline and two post-intervention periods	Medium

Authors (Year of publication)	Study Type	Population (Sample size)	Intervention	Comparison	Outcome(s) of interest (Outcome measure(s))	Evaluated quality of publication (High, Medium or Low)
Gao, J. (2010)		community in New York State (n=158, mean age 73.94)	telephone conference call and incorporating (a) education about dementia and its symptoms and about caregiving skills and resources to address these symptoms, (b) emotion- and problem-focused coping strategies, and (c) group support.		(data abstracted from Veteran's Association (VA) records)	